

Smartphones in ophthalmology

Jay Chhablani, Simon Kaja¹, Vinay A Shah²

The potential usefulness of smartphones in the medical field is evolving everyday. This article describes various tools available on smartphones, largely focusing on the iPhone, for the examination of an ophthalmic patient, for patient and physician education, as well as reference tools for both ophthalmologists and vision researchers. Furthermore, the present article discusses how smartphones can be used for ophthalmic photography and image management, and foremost, the usefulness of the applications such as the Eye Handbook for the ophthalmologist and interested students, patients, physicians, and researchers, currently available in the iPhone.

Key words: Android, eye handbook, iPhone, smart phone, testing tools

Access this article online

Website:

www.ijo.in

DOI:

10.4103/0301-4738.94054

Quick Response Code:



The last few years have seen tremendous advances in the field of cell phones and other mobile technological gadgets. Physicians are not to be left behind in this technological explosion and these days, cell phones are often just as much a standard issue for new physicians as are new pagers and new on-call schedules. Ophthalmologists are no exception.^[1,2]

A smartphone is a mobile phone with advanced computing ability to run multiple advanced applications. Smartphones have been reported to be used in patient care in various medical specialties.^[3] It is estimated that one out of every two physicians uses a smartphone and this number is expected to rise.^[4] In the United States it is estimated that about 81% of physicians will be using a smartphone by 2012. Smartphones have a growing utility in the field of ophthalmology.^[5] Last year, ASCRS (American society of Cataract and Refractive Surgeons) survey demonstrated that approximately 83% of members use smartphones to accomplish their professional responsibilities.^[6] One of the reasons for this boom is the large number of medical “apps” or applications that are available. It may be difficult in this day and age to keep up with the latest information available in the field of medicine and a medical “app” that is able to collect the data and effectively sort it and present it in a user-friendly manner will definitely be appreciated for its ability to allow efficient use of the physician’s time.

In this article, we have attempted to include the description of various useful applications available on the smartphone, in particular, the iPhone (Apple Inc., Cupertino, CA, USA), for

ophthalmologists and vision researchers. The iPhone may have many potential functions in the field of ophthalmology and its uses may be classified into the following broad categories.

Tools for the Clinical Ophthalmologist

- Testing tools
- Patient education tools
- Physician reference tools
- Physician education tools
- Calculators and other office-based tools

The iPhone will be able to integrate several clinical evaluation tools in common use and create a single user-friendly interface.

1. Testing tools: The iPhone has the potential to combine many commonly used clinical evaluation tools into one easy-to-use interface. Testing tools constitute near vision cards, color vision plates, a pupil gauge and ruler, a pen light, a fluorescein light, pediatric fixation targets, Amsler grids, a Worth 4 Dot test and accommodation targets, red desaturation tests, and an OKN drum simulator [Fig. 1a and b]. While these tools will not replace office-based testing under ideal conditions, they can be particularly useful, especially in the setting of inpatient consults and emergency room visits. There are several apps available for the iPhone that can perform various testing modalities. However, “Eye Handbook” (EHB) is one of the most comprehensive ophthalmology applications available (free application) and provides most of the above-mentioned examination tools.^[7]

The following are some of the tools that are currently available or have the potential to be used with iPhone:

- Near vision cards, color vision plates, and pupil gauge – These tools are available on the smartphone and can be used in situations where other tests of visual acuity are not readily available, e.g. inpatient or emergency room settings. Tools like color plates will not fade over time on the smartphone as they would in print.

Shiley Eye Center, University of California, San Diego, CA, ¹Vision Research Center and Department of Ophthalmology, University of Missouri – Kansas City, School of Medicine, Kansas City, MO, ²Department of Ophthalmology, McGee Eye Institute, University of Oklahoma, Oklahoma City, OK, USA

Correspondence to: Dr. Vinay A. Shah, Vitreoretina Service, Dean McGee Eye Institute, Department of Ophthalmology, University of Oklahoma, Oklahoma City, OK, USA. E-mail: drvinayshah@gmail.com

Manuscript received: 23.01.11; **Revision accepted:** 02.01.12

This may potentially avoid inaccurate results. The ophthalmologist should remember that all the testing tools are not ideally standardized and should be used by the eye care professional using their professional judgment.

- Fluorescein light and pen light –These tools will have most of their utility in non-ideal patient exam settings. The physician will have to increase the screen brightness to its maximum and reduce the surrounding light to its minimum.
 - Pediatric fixation targets – Having various fixation targets that are bright with motion and sound to entertain pediatric patients is a great asset to have at your disposal. These tools on the smartphone engage the pediatric patient very well during the exam [Fig. 1c].
 - Other useful tools on the smartphones are Worth 4 Dot and accommodation targets, Amslers grid, pediatric optotypes, and red desaturation test, among others, that are very useful in non-office-based settings.
2. Patient education tools: Patient education is an important part of patient management. Usually instruction sheets, brochures, and videos about medical conditions are used for the better understanding of the patients. Various apps are available on the iPhone with high-resolution images of the various ocular conditions that explain anatomy and pathology as well as various treatment procedures and options to the patient.
- Within the “Eye Handbook”, (EHB) the eye movie provides a three-dimensional rendering of a rotating eyeball whereby the physician can delineate specific anatomical considerations in medical or surgical disease management. The “most common” is a useful list of various common ocular disease conditions that are encountered in day-to-day ophthalmology practice. It includes a short description of clinical features and treatment options of the disease [Fig. 1d]. It also has a small list of relevant and credible patient education websites for the patients to learn more about the diagnosis. The specific information can be emailed to the patient.^[8]
3. Physician reference tools: Smartphones can be very effectively used as a reference tool in the clinic or in any patient care setting. At the tip of your finger, you may have classifications and grading systems such as angle anatomy, iritis severity, diabetic retinopathy, macular holes, optic nerve edema, and melanoma. Other useful sections may be definitions, differential diagnosis, driving license and legal blindness standards for each state, as well as workups for common ocular diseases.
4. Physician education: The smartphone could provide various physician education modalities available at any time. Great resources include a list of diagnoses not to miss, a color-coded diagram of retinal drawings, questionnaires for commonly encountered ophthalmic diseases, and a summary of benchmark randomized control trials in ophthalmology, such as Collaborative Initial Glaucoma Treatment Study (CIGTS),^[9] Normal Tension Glaucoma Study (NTGS),^[10] Advanced Glaucoma Intervention Study (AGIS),^[11] Early Manifest Glaucoma Trial (EMGT),^[12] and Ocular Hypertension Treatment Study (OHTS).^[13] Making and uploading your own study flash cards, while studying for the board examination on your smartphone is an

invaluable feature for ophthalmologists in training.

Clinical trial information is also available literally at fingertips, by a growing number of apps that feature access to clinical trial databases. The app “Clinical Trials” (StopWatch Media Inc., Philadelphia, PA, USA) utilizes databases by the National Library of Medicine and National Institutes of Health to list over 86,000 clinical trials registered with the US government. With similar search options and limiters as in a regular complex web interface, the Clinical Trials app offers advanced search options, including type trial (observational, interventional, or expanded access), location, clinical trial phase, and enrolment status. Various email features within the app are designed for emailing both individual trial information and an entire list of relevant trials using the iPhone’s email interface, allowing easy sharing of the information with patients and colleagues.

5. Calculators and other office-based tools: There are multiple applications on the iPhone that address this area. They include the useful utilities such as a glaucoma risk calculator, back vertex distance calculator, and an IOL calculator, amongst others. There are various apps on ophthalmic coding that allow the user to search various CPT and ICD codes (e.g. STAT ICD-9, Austin Physician Productivity, LLC, ICD 9, A1 Technology Inc.).

One alternative feature of office-based tools is photography. Newer smartphones have camera resolutions up to 8-megapixel. In circumstances, like within the emergency area, a smartphone is often used to document external pictures of the attention, slit-lamp photos of the anterior phase, fundus biomicroscopy, and indirect ophthalmoscopy findings [Fig. 2a–c]. Recording of anterior and posterior segment surgeries is also made very easy by this tool^[2] [Fig. 2d]. Video can be recorded by keeping the iPhone approximately a centimeter away from the eyepiece of the microscope after focusing the image.

In addition, smartphones will display suitable images of magnetic resonance imaging and computed tomography scans directly from a liquid crystal display (LCD) computer monitor. The iPhone and other smartphones also have the ability to capture video of eye movements, which is of acceptable quality. In an emergency setting, adequate quality photography can be acquired and emailed to a specialist or attending physician directly from the phone to get consultation and advice. This is a great asset for trainees.

Tools for the Vision Researcher

Besides the variety of clinical applications discussed herein, the presence of smartphones in the basic science laboratory has significantly increased, replacing timers, calculators, and other small digital aids. Moreover, the number of specialized basic science applications has steadily grown over the recent years. However, it is difficult to estimate the total number of scientific apps currently available for iPhone and iPad as apps may be categorized as reference, medical, productivity, or utility app.

Many manufacturers now also provide iPhone or Android apps. While some are mere smartphone versions of online catalogs, others include technical references and animated tutorials for a variety of equipment and consumables used in a modern vision research laboratory.

In addition, a growing number of apps feature basic data viewing, protocol editing, and analysis capabilities, sometimes even combined with various degrees of remote protocol features for networked equipment.

Useful Smartphone and iPhone Applications

The EHB

This is the most comprehensive iPhone application available on iTunes and Android Stores, which can be downloaded for free. This app has all the above-mentioned tools, along with eye atlas, link to meetings and various societies, and ophthalmic instruments information. Several references to ophthalmic genetics, ophthalmic acronyms and eponyms, differential diagnosis and classifications, ophthalmic dictionary, and mnemonics are also available. Various coding systems including ICD-9, E and M, and CPT codes can be accessed [Fig. 3]. Important journals with access to their websites and contents are available on EHB. Treatment section of EHB has ophthalmic medications, preparation of the fortified antibiotics, and laser settings for ophthalmic procedures. Free download of lectures, flash cards and patient and physician educational movies are available. Through its collaboration with the American Academy of Ophthalmology, educational videos, Eye Net, the blink quiz and summary benchmarks are now available to anyone in the world on their smartphone. Access to the O.N.E. Network (ophthalmic News and Education Network) is also available. An interface to the EyeWiki has also been enabled. Media consent, is a great asset, can be attainable right on the screen by the patient providing a digital signature. This document could be emailed and added to their medical record. The EHB is being used worldwide, with about 50% of downloads in North America, 20% in Europe, and 10% each in Australia and Asia.^[14]

Recent Applications

EyeRoute ophthalmic image management system

The EyeRoute Ophthalmic Image Management System (Anka Systems Inc./Topcon Medical Systems Inc. McLean, VA) has the capacity to combine images and reports from over a hundred different manufacturing systems including Topcon into a uniform, single digital database which is also secure. It allows the user to not only view but also compare and transmit patient images smoothly. It is basically a web browser based system that provides the user with quick access to patient-related information from any location and at any time with the help of the iPhone. It is capable of integration with most of the EMR systems in use and is designed to help in the conversion to a paperless environment. EyeRoute is fully standard compliant, flexible, and scalable.

Patient images which are stored in EyeRoute may be accessed easily with the help of the EyeRoute® Mobile's touch screen. These images may be sorted by modality and date of visit, and may be viewed, zoomed, or enhanced. The user will also be able to add text annotations and make use of the audio dictation option provided. When a patient image has been reviewed, this information may be shared with other users who have access to EyeRoute.^[15]

PubMed on tap

PubMed on Tap (Serhiy Duminskyi® 2009, References on Tap)

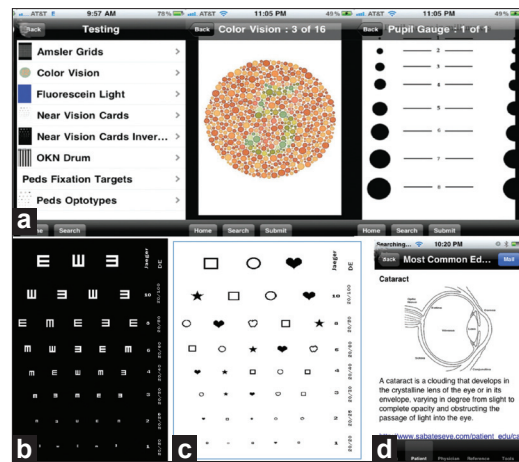


Figure 1: iPhone screen shots: (a) Various testing tools available on iPhone; (b) color vision tool; (c) pediatric optotypes; (d) disease description panel in patient education section

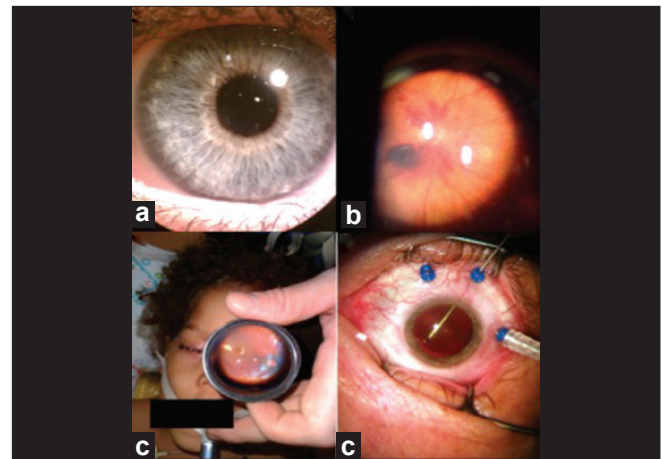


Figure 2: iPhone screen shots: (a) iPhone slit-lamp photograph; (b) and (c) iPhone indirect photographs taken using a 20D (Volk Optical Inc., Mentor, OH, USA) lens; (d) snapshot of video recording through an operating microscope with an iPhone



Figure 3: iPhone screen shots: (a) Home screen of Eye Handbook showing various applications; (b) coding application; and (c) physician reference application on Eye Handbook

is an application on iPhone, which allows to search PubMed while on the go. PubMed on Tap is an easy-to-use app that has a built-in interface to search PubMed, the library of the National Institutes of Health. Full text of references (based on subscriber status) is accessible through a built-in web interface. PDF files can be downloaded, saved in a personal, fully searchable library, and emailed directly using the iPhone's built-in email service. The personal library can be formatted so that it can be easily imported into reference management applications such as EndNote, Reference Manager, or Bookends.

Dragon dictation

Dragon Dictation 2.0 (Dragon® NaturallySpeaking®) is a voice recognition software which allows the user to speak into the phone and enables instant conversion to text content. It is easy to use and applicable for everything in our iPhone, from emails to blog posts. In fact, it is up to 5 times faster than typing on the keyboard. The new Dragon Dictation 2.0 also features multilingual capabilities.^[16]

Flash card

Reference materials like study flash cards can be very useful for board review. G Flash pro app has the facility to create customizable personalized flash cards. The app allows integration with programs such as Google docs and allows the users to create personal study material which may be modified to each individual's need, at any time and from anywhere. "Ophthalmology Clinical Medicine" is an application available on the iPhone, which also provides study flash cards. The Eye Handbook also provides some prepopulated ophthalmology flash cards that may be useful to trainees and physicians looking for review material for certification and recertification purposes.

Skyscape medical resources

Skyscape Medical Resource app (Skyscape, Inc.) contains free medical information and decision support resources for medical professionals. EHB has provided few Skyscape paid apps including Wills Eye Manual, Mass Eye and Ear Illustrated Manual of Ophthalmology, Evidence Based Medicine Guidelines – Ophthalmology, and Cochrane Reviews in Eyes and Vision. Skyscape's patented SmartLink technology combines all resources into an intelligent whole by cross-referencing freely among them, which helps in the greatest degree of decision support at the point of care.

IKONION

IKONION (IKONION Digitale Medien GmbH) is yet another application available on the iPhone, which proves to be very useful in patient education. This application may be downloaded by patients wanting more information about their disease process. It provides patients with a brief description of eye diseases along with high-resolution pictures, videos, and animations which facilitate a better understanding of common eye conditions like cataract. These images can be used by physicians in the office to explain patients about various ophthalmic conditions.^[8]

Android Phone and Ophthalmology Applications

Android is the operating system for smartphones by Google. Its google market is comparable to the Apples iTunes store with

regards to availability of various ophthalmology applications. Various applications like ophthalmology glossary, advanced eye charts, Skyscape, Wills eye manual, color blindness test, glaucoma calculator, ophthalmological societies, PubMed Mobile Pro, eye quiz, medical terminology flash cards, ICD9 / ICD10 medical code search, Taber's medical dictionary, etc. are available for Android phones.^[17] Since fall of 2011, the EHB is available for Android devices, free of charge.

Recent versions of Android operating system include 2.0/2.1 (Éclair), 2.2 (Froyo), 2.3 (Gingerbread), and 3.0 (Honeycomb). Android 3.0 is a tablet-oriented platform, which supports large screens, multitasking, and high-performance 2D–3D graphics. The upcoming version is Android 2.4 (Ice Cream Sandwich), which is a combination of Gingerbread and Honeycomb and will reduce the gap between a tablet and phone. This version would have improved multimedia features. Enhanced graphics and better illustrative representation in this new version would be of immense use in medical field, especially Ophthalmology.^[18]

Personalized Physician Apps (Marketing and Branding Your Practice)

Ten years ago the question was "Do I need a website" now a days if you are not present on the web it is as if you don't exist. Considering this immense proliferation of smartphones and the use of applications in day-to-day life (by some estimates smartphones are more used than computers) the time has come for the physician and ophthalmologist to consider that "do I need an App?". Personalized apps (e.g. Doctor App, Eyedocapp, etc) can allow the patient to access their doctor through their app request or change their appointment, refer a friend or patient or just access patient education material that the doctor has loaded on his or her app. Apps can give the opportunity for the doctor to communicate with their patients via "push notification".

Limitations

Usage of mobile devices to transfer patient data should be done securely using message encryption; appropriate documentation of patient consent must be obtained. Special consideration should be given to patient confidentiality.

Furthermore, health and safety concerns have become a growing problem. Smartphones are used in the clinical setting, in the laboratory, as well as at home. In order to avoid contamination, remember to disinfect the device regularly and never use the device when you are wearing gloves. Also, do not put down the device on worktops in examination rooms and laboratory benches.

Conclusions

Smartphones have a number of useful applications for any medical professional, but ophthalmology uniquely requires several testing tools for a basic patient exam. Besides being a communication device, smart phone now has testing tools for ophthalmologists especially for imperfect examination situations Smartphone applications in ophthalmology have great functionality and vast potential for future growth.

The ophthalmic utility of smartphones can still evolve and improve over time. This dynamic interface has a pleasant functionality nowadays, and possible future growth within

the field of ophthalmology. Smartphone applications in ophthalmology appear as if they'll have a larger role to play on a daily basis, in patient care and education.

Acknowledgment

Generous support by the Department of Ophthalmology and the Vision Research Center, University of Missouri – Kansas City, is gratefully acknowledged.

References

- Shah VA, Lord RK, Kaja S. Smartphones in Ophthalmology (Workshop). Association for Research in Vision and Ophthalmology Annual Meeting 2010, Fort Lauderdale, FL; Program #487.
- Lord RK, Shah VA, San Filippo AN, Krishna R. Novel Uses of Smartphones in Ophthalmology. *Ophthalmology* 2010;117:1274.
- Low DK, Pittaway AP. The 'iPhone' induction - A novel use for the Apple iPhone. *Paediatr Anaesth* 2008;18:573-4.
- More Physicians Use Smartphones, PDAs in Clinical Care. *ihealthbeat.org* [Internet]. California HealthCare Foundation, Oakland (CA). Available from: <http://www.ihealthbeat.org/Articles/2009/1/6/More-Physicians-Use-Smartphones-PDAs-in-Clinical-Care.aspx>. [Last cited 2009 Nov 19].
- Manhattan Research [Internet]. New York. Available from: http://www.manhattanresearch.com/newsroom/Press_Releases/physician-smartphones-2012.aspx. [Last cited 2011 Jan 10].
- Davis EA, Hovanesian JA, Katz JA, Kraff MC, Trattler WB. Professional Life and the Smartphone. *Cataract Refract Surg Today* 2010;Sept 21-2.
- Shah VA, Lord RK, San Filippo AN. Smartphones in Ophthalmology: Potential Uses of the Smartphone in Your Practice. Pearls in Ophthalmology [Internet]. Available from: <http://www.medrounds.org/ophthalmology-pearls/2010/02/smartphones-in-ophthalmology-potential.html>. [Last cited 2010 Feb].
- Shah VA, Lord RK, San Filippo AN. Smartphones in Ophthalmology: Potential Uses of the Smartphone in Your Practice. Pearls in Ophthalmology [Internet]. Available from: <http://pio.medrounds.org/component/content/article/39-technology-pearls/74-smartphones-in-ophthalmology-potential-uses-of-the-smartphone-in-your-medical-practice-.html>. [Last cited 2010 Jul].
- Clinicaltrials.gov [Internet]. Bethesda, Maryland: U.S. National Institutes of Health; NCT00000149. Available from: <http://clinicaltrials.gov/ct2/show/NCT00000149>. [Last cited 2011 Jan 10].
- Clinicaltrials.gov [Internet]. Bethesda, Maryland: U.S. National Institutes of Health; NCT00832377. Available from: <http://clinicaltrials.gov/ct2/show/NCT00832377>. [Last cited 2011 Jan 10].
- Clinicaltrials.gov [Internet]. Bethesda, Maryland: U.S. National Institutes of Health; NCT00000148. Available from: <http://clinicaltrials.gov/ct2/show/NCT00000148>. [Last cited 2011 Jan 10].
- Clinicaltrials.gov [Internet]. Bethesda, Maryland: U.S. National Institutes of Health; NCT00000132. Available from: <http://clinicaltrials.gov/ct2/show/NCT00000132>. [Last cited 2011 Jan 10].
- Clinicaltrials.gov [Internet]. Bethesda, Maryland: U.S. National Institutes of Health; NCT00000125. Available from: <http://clinicaltrials.gov/ct2/show/NCT00000125>. [Last cited 2011 Jan 10].
- Khanna R. The Eye handbook. *Glaucoma Today* [Internet]. Available from: <http://bmctoday.net/glaucomatoday/2010/10/article.asp?f=the-eye-handbook>. [Last cited 2011 Jan 10].
- EyeRoute Mobile is First iPhone App for Ophthalmic Image Management [Internet]. Redondo Beach. U.S. Available from: http://publishersnewswire.com/2010/05/07/PNW1850_100223.php. [Last cited 2011 Jan 10].
- Dragon Dictation [Internet]. Cupertino. U.S. Available from: <http://itunes.apple.com/us/app/dragondictation/id341446764?mt=8#>. [Last cited 2011 Jan 10].
- Android.com [Internet]. California. U.S. Available from: https://market.android.com/details?id=apps_topselling_paidandcat=MEDICAL&start=0&num=24. [Last cited 2011 Jan 10].
- AndroidNG.com [Internet]. Available from: <http://www.androidng.com/android-ice-cream-features-release-date>. [Last cited 2011 Jan 10].

Cite this article as: Chhablani J, Kaja S, Shah VA. Smartphones in ophthalmology. *Indian J Ophthalmol* 2012;60:127-31.

Source of Support: Department of Ophthalmology and the Vision Research Center, University of Missouri – Kansas City.

Conflict of Interest: None declared.

Staying in touch with the journal

1) Table of Contents (TOC) email alert

Receive an email alert containing the TOC when a new complete issue of the journal is made available online. To register for TOC alerts go to www.ijo.in/signup.asp.

2) RSS feeds

Really Simple Syndication (RSS) helps you to get alerts on new publication right on your desktop without going to the journal's website. You need a software (e.g. RSSReader, Feed Demon, FeedReader, My Yahoo!, NewsGator and NewzCrawler) to get advantage of this tool. RSS feeds can also be read through Firefox or Microsoft Outlook 2007. Once any of these small (and mostly free) software is installed, add www.ijo.in/rssfeed.asp as one of the feeds.